

1,178,144



# PATENT SPECIFICATION

DRAWINGS ATTACHED

1,178,144

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## COMPLETE SPECIFICATION

### Improvements in or relating to Electrochemical Units

We, LEESONA CORPORATION, a corporation organized and existing under the laws of the Commonwealth of Massachusetts, United States of America, of 333 Strawberry Field Road, Warwick, State of Rhode Island, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, 10 to be particularly described in and by the following statement:—

This invention embraces improved air or oxygen depolarized electrochemical units for the electromechanical generation of electrical current. More particularly, the invention is directed to an improved anode assembly for use in a battery of air or oxygen depolarized cells of the type described in British patent application No. 1430/66 (Serial No. 1,138,468) and British 15 patent application No. 55794/66 (Serial No. 1,176,486). The improved anode assembly permits the construction of a battery of air or oxygen depolarized cells having replaceable anodes wherein the construction 20 of the cell is simplified and wherein the anodes can be conveniently replaced once the metal anode has been consumed.

The metal/air and metal/oxygen electrochemical batteries described in the aforesaid patent specifications permit a compact battery construction to provide a high energy to density ratio and have a rapid rate of discharge and charge. Moreover, 25 since the anodes of the cells are replaceable, the batteries can be restored in the field, using a recharge kit, without need of an external DC power source. As a result of the aforesaid, the batteries are an excellent 30 source of power for communication units and vehicles in field operation and in space systems.

The ability to obtain the high discharge-

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charge rate in the aforesaid batteries is primarily a result of the novel and highly 45 efficient cathodes which comprise a hydrophobic polymer membrane, such as polytetrafluoroethylene, which is gas permeable but impermeable to liquids and a catalytic 50 layer on one surface of the membrane which is in contact with the electrolyte of the cell. The anodes can be of any metal which is more electro-positive than oxygen. Preferred 55 anodes are porous zinc and porous magnesium structures wrapped in a hydrophilic membrane such as fiber reinforced cellulose. The anode is positioned within the cathode and separated therefrom by means of an electrolyte. Preferably, the electrolyte is 60 trapped in a suitable matrix such as the wrapping of the anode. Clamps are provided to hold the anode and cathode in operable association.

In operation, air or oxygen passes through the polymer membrane, ionizes at the catalytic layer, accepting electrons and forming hydroxyl ions which are transferred to the anode to complete the electrochemical reaction. A representative reaction where zinc is employed as the anode and the cell fed 70 with oxygen is as follows:

At the cathode  
$$\frac{1}{2} \text{O}_2 + \text{H}_2\text{O} + 2e \longrightarrow 2 \text{OH}^-$$

At the anode  
$$\text{Zn} + 2 \text{OH}^- \longrightarrow \text{ZnO} + \text{H}_2\text{O} + 2e$$

Total cell reaction  
$$\text{Zn} + \frac{1}{2} \text{O}_2 \longrightarrow \text{ZnO}$$

When the zinc anode is completely or substantially completely oxidized to the oxide, the anode is replaced by loosening suitable retaining means on the battery, removing the anode and inserting a new anode.

Since the cathode remains unchanged as a result of the electrochemical reaction, it does not require a separate charging step. Preferably, new electrolyte will be furnished 5 to the cell at the time the anode is replaced, for example, by saturating the porous anode and/or a hydrophilic membrane or matrix around the anode.

Although the aforesaid batteries are exceptionally useful, one area permitting improvement is the more rapid replacement of the anodes in field operation. Preferably, a 60-watt 32-volt battery should be capable of being reactivated, i.e., the consumed 10 anodes removed and new anodes inserted, in no more than about ten minutes. Therefore, it is desirable to have a few replaceable components in a cell as necessary. However, in order to fulfill the voltage and current density requirements, it is necessary that the anode and cathode units be constructed in relatively small units rather than in large unitary designs. More specifically, 15 a 28-cell battery (operating at a nominal 1.2 volts per cell) would consist of 28 separate bi-cells, each bi-cell consisting of 2 cathodes connected in parallel and capable of accommodating a single anode recharge. Each cell would then deliver its 20 nominal voltage and the net voltage for the battery would be 32 volts. Following discharge of the battery, it would be necessary to remove 28 discharged anodes and to replace these with 28 new anode charges. 25 thereby requiring a total of 56 individual actions to recharge or reactivate the battery.

Accordingly, it is an object of the present invention to provide air or oxygen depolarized electrochemical units having replaceable modular anodes permitting rapid and convenient replacement.

It is another object of the invention to provide air or oxygen depolarized electrochemical units comprising an envelope 45 cathode and a modular anode for insertion in said cathode.

It is another object of the invention to provide air or oxygen depolarized electrochemical units comprising an envelope 50 cathode, an electrolyte and a split, porous modular anode permitting more rapid reactivation.

These and other objects of the invention will become more readily apparent from 55 the following detailed description, with particular emphasis being placed upon the drawing.

The aforesaid objects of the invention are accomplished by utilizing a modular 60 cell construction and modular anode recharges in the construction of a metal/air or metal/oxygen depolarized electrochemical unit comprising an envelope cathode, an anode, and an electrolyte separating the 65 anode and cathode. By employing the afore-

said design, the number of individual actions needed to recharge or reactivate a battery can be reduced by one half or more. According to the present invention, the envelope cathode will comprise four cathodes capable of forming two separate bi-cells, i.e., two cathodes in each cell connected in parallel and insulated from the next cell, or four individual cells with one cathode being available for each cell. The anode 70 recharge comprises two anodes having a common non-conductive top portion. Further, according to the present invention, each anode can be bi-sected with an insulating material, thereby converting the 75 aforementioned two-cell anode into a four-cell anode. By providing as much anodic material on each side of the insulator as was previously present in the anodes described, it is possible to deliver the same 80 capacity of current at a higher voltage by proper series connection. In effect, the 85 number of anode replacements required in the 12-volt battery is reduced from 12 to six or three, depending upon which embodiment is employed. As apparent, therefore, the number of individual actions and, thus, the time necessary to recharge or reactivate a battery in the field is substantially 90 reduced.

The improved modular construction of the electrochemical units of the present invention will be more readily apparent from the accompanying drawing wherein like numerals are employed to designate like 95 parts and wherein Figure 1 is an exploded perspective view of one embodiment of the improved cell and Figure 2 is a perspective view of a second embodiment of the improved cell, with the anode being partly 100 broken away.

More specifically, referring to Figure 1 of the drawing, reference numeral 1 is directed to the complete modular anode comprising an integral non-conducting top 105 1.1 and two individual anodes 1.4. Handles 1.3 are provided for the convenient replacement of the modular anode. Envelope cathode 2 comprises a frame 2.1, a hydrophobic membrane 2.2, and a conductive 110 support screen 2.4 which is on the internal side of the membrane but in view of the thinness of the membrane the configuration of the screen is apparent from the outer surface of the membrane. The envelope cathode is separated into two parts by means of insulating member 2.3. The modular anode of the electrochemical unit fits into the envelope cathode 2 and is held in place by suitable retaining means not shown. 115 Preferably, a glassine paper, or fiber reinforced cellulose, completely covers the anode and electrically insulates the anode from the bi-cathode. If the anode is porous, sufficient electrolyte can be retained in the 120 125 130

anode and anode wrap to fulfill the needs of the cell. In the event a sheet metal anode is selected, the electrolyte can be added to the pocket of the bi-cathode and 5 allowed to saturate the anode wrap after the anode is in place or the anode wrap can be saturated with electrolyte prior to insertion of the anode. Anode lead 1.2 is connected to an adjacent cathode lead 2.5 10 by means of a suitable socket, not shown.

Figure 2, which is an exploded view partly in section of a second embodiment of the modular construction, illustrates a unit wherein the anode has been bi-sected with 15 insulating material 1.5. As is apparent from the drawing, the thickness of the total anode has been increased as has been the thickness of the envelope cathode. Thus, insulating member 1.5 extends throughout the 20 anode and electrically separates the two surfaces of the anode from each other. The insulating member extends beyond the outer surfaces of the anode to form a ridge, which ridge fits into slot 2.6 of the envelope cathode 25 to provide a fluid-tight tongue and groove association. It may be desirable to include a support frame 1.6 around the anode to preserve its mechanical integrity. Although it is preferred that the insulating member 30 1.5 and support frame 1.6, if employed, be constructed as an integral unit, it is possible to construct them as individual components and thereafter assemble the entire modular anode. It is essential, however, 35 that the seal between the faces of the envelope cathode and the separate portions of the bi-sected anode be fluid-tight to prevent electrolyte seepage from one compartment to the other compartment. For this 40 reason, it may be desirable to employ seals, not shown, to ensure fluid-tightness.

The insulating materials which are employed in fabricating the envelope cathode frame, the anode frame, and the battery top 45 can be any insulating material which is capable of withstanding the environment of use. Thermo-setting and thermo-plastic epoxy resins such as those obtained from the condensation reaction of bisphenol A 50 [2,2-bis(4-hydroxyphenyl) propane] and epichlorohydrin are particularly suitable. However, other resins can be employed such as the phenol-formaldehyde and urea-formaldehyde thermo-plastic or thermo-setting 55 resins. Such materials are readily available and known to one skilled in the art.

The bi-cathode as more fully described in the aforesaid British patent specification No. 1,138,468 comprises a hydrophobic 60 membrane which is in contact with a conductive metal support screen or mesh and a catalytic layer. The membrane which is to be used can be any material which is hydrophobic and permits the passage of 65 gas, but precludes the flow of aqueous

materials. Exemplary materials are the polymers of fluorinated hydrocarbons such as polytetrafluoroethylene, polytrifluoroethylene, polyvinylfluoride, polyvinylidenefluoride, polytrifluorochloroethylene, the hydrophobic 70 co-polymers of two or more of the monomers of the above materials or co-polymers of such monomers with e.g. acrylonitrile, methacrylate, or ethylene. The polymers normally will have a porosity of from about 75 15 to 85 percent and a uniform pore size distribution of from about 0.01 to about 100 microns, and a thickness of about 0.5 to 10 mils. The catalysts used to coat the 80 hydrophobic polymers are the pure elements, alloys, oxides, or mixtures therof which are effective in promoting an electrochemical reaction. More specifically, operable materials include the elements, alloys, oxides, or mixtures of Group IB, IIB, IV, 85 V, VI, VII, and VIII metals of the Mendeleev's Periodic Table. Metal blacks admixed with a hydrophobic polymer, such as polytetrafluoroethylene, rolled into the 90 conductive metal support screen are preferred. The metal support screen can be any material which conducts an electrical current and which will withstand the corrosive environment of the battery. Such 95 materials include nickel, zirconium, titanium, and tungsten screens or expanded meshes. Moreover, it is possible to apply a hydrophilic polymer or other suitable hydrophilic material such as paper, over the catalytic 100 layer which will be in contact with the electrolyte of the battery when in operation.

The anodes which are to be used herein can be any conventional solid electroconductor employed in a metal/air or metal/oxygen cell such as metals, metalloids, alloys, 105 and the heavy metal salts. It is only essential that the material selected be chemically reactive with a compatible electrolyte and be more electro-positive than oxygen. Such materials include lead, zinc, iron, cadmium, aluminum, and magnesium. From the standpoint of cost, capacity, and convenience, zinc is the preferred material. Although the anode can be in the form of a solid, or substantially solid metal sheet, it is preferred 110 that the anode be porous. Porous anodes can be made, for example, by sintering selected metal powders.

The cells will operate on conventional electrolytes including the alkaline materials such as sodium hydroxide, potassium hydroxide, and mixtures of potassium and ribidium hydroxide. Acid electrolytes including sulfuric acid, phosphoric acid, and hydrochloric acid can be employed. As is apparent, depending upon the particular electrolyte used, different anode materials can be selected. It is also feasible, and at times desirable, to employ an electrolyte which is trapped in a suitable matrix such 115 120 125 130

as those made up of hydrophilic polymers or ceramic materials.

WHAT WE CLAIM IS:—

- 5 1. A metal/air or metal/oxygen electrochemical unit comprising an envelope cathode and a replaceable modular anode positioned within said cathode, said cathode comprising at least four individual surfaces, 40
- 10 at least two of said surfaces being electrically insulated from the second two surfaces and said modular anode comprising at least two anode units spaced apart and electrically insulated from each other having a common 45 non-conductive top portion constructed and arranged in order that cathode surfaces and anode surfaces are in operable association.
- 15 2. The electrochemical unit of Claim 1 50 wherein the envelope cathode comprises a hydrophobic member and a conductive catalytic coating on the inner surface of said member.
- 20 3. The electrochemical unit of Claim 1 55 or Claim 2 wherein the anode is porous.
- 25 4. The electrochemical unit of Claim 2 or Claim 3 wherein the hydrophobic member comprises polytetrafluoroethylene.
- 30 5. The electrochemical unit of any one 60 of Claims 1 to 4 wherein the anode is made of zinc.
- 35 6. The electrochemical unit of any one 65 of Claims 1 to 5 wherein said four individual surfaces of said cathode are each electrically insulated from the other and the two anode units of said modular anode are bi-sected with an insulating member form-

ing four individual anode surfaces, said four anode surfaces being electrically separated from each other.

7. The electrochemical unit of Claim 6 wherein the insulating member projects beyond the outer surface of the anode to form a ridge which fits into a slot in the envelope cathode to provide a fluid tight tongue and 45 groove seal.
8. The electrochemical unit of any one of Claims 1 to 7 wherein the electrolyte is trapped in a matrix.
9. The electrochemical unit of Claim 8 50 wherein the matrix is attached to the cathode.
10. The electrochemical unit of Claim 8 wherein the matrix is attached to the anode.
11. The electrochemical unit of any one 55 of Claims 1 to 10 wherein said cathode comprises a hydrophobic polymer member in contact with a conductive metal screen and the conductive catalytic coating is rolled into said screen.
12. The electrochemical unit of Claim 11 60 wherein the catalytic coating is an admixture of an electrochemically active metal black and colloidal polytetrafluoroethylene.
13. The electrochemical unit substantially as hereinbefore described, with reference 65 to and illustrated in the accompanying drawings.

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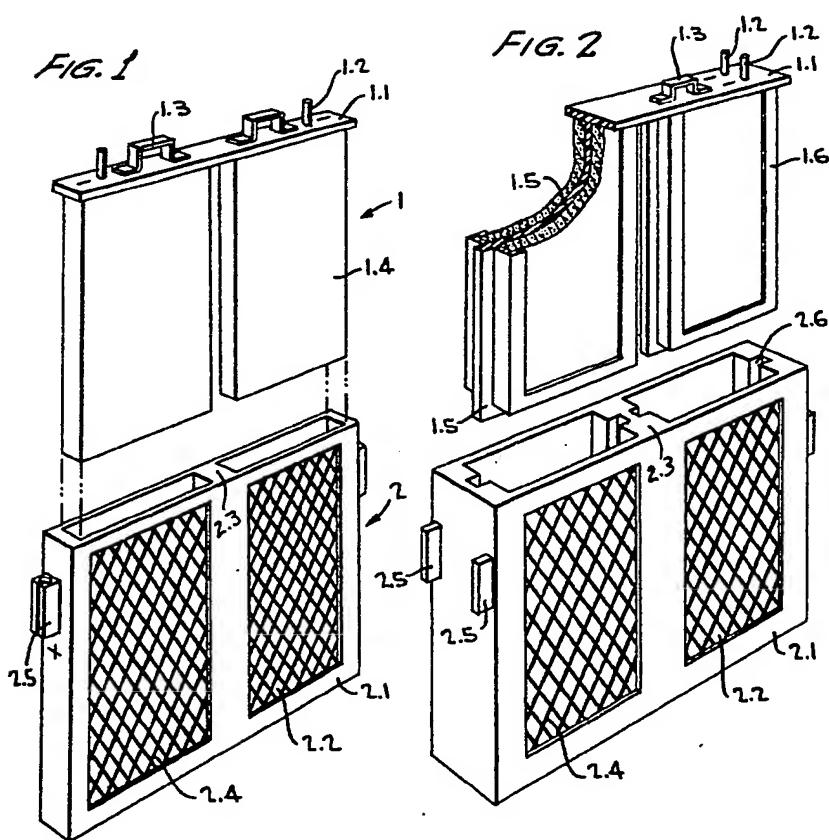
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1 SHEET

COMPLETE SPECIFICATION

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